

Mapping and predicting benthic habitats in estuaries using towed underwater video

Thesis submitted by

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Certificate

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree.

I also certify that the thesis has been written by me and that any help that I have received in the research or preparation of the thesis, and all sources used, have been appropriately acknowledged.

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Table of Contents

Acknowledgements.....	iii
Table of Contents	v
List of Figures.....	vii
List of Tables	ix
Abstract.....	xi
Chapter 1: General Introduction.....	2
1.1 Importance of estuaries	2
1.2 Estuaries in south-west Australia.....	6
1.3 Study area.....	8
1.4 Aims and objectives	10
Chapter 2: A review of video methods to characterise seafloor systems, with application to south-west Australian estuaries.....	14
Abstract.....	14
2.1 Introduction.....	14
2.2 Strengths and weakness of each approach to estimate biological abundance and cover ..	20
2.2.1 Point counts.....	20
2.2.2 Digital segmentation of habitats within still images	22
2.2.3 Automatic classification.....	23
2.2.4 Visual estimation.....	24
2.2.5 Categorical classification	27
2.3 Discussion.....	28
Chapter 3: Quantifying and predicting the distribution and abundance of key habitat-forming biota across five estuaries in south-west Australia	32
Abstract.....	32
3.1 Introduction.....	32
3.2 Methodology	37
3.2.1 Study areas	37
3.2.2 Survey design.....	40
3.2.3 Towed video and drop camera survey	43
3.2.4 Data analysis	50
3.3 Results.....	53
3.3.1 Physical and spatial setting	53
3.3.2 Benthic habitat composition from video analysis	58
3.3.3 Random Forests predictions for key species of seagrass and invertebrates	64

3.3.4 Model Performance vs. validation dataset.....	77
3.4 Discussion.....	81
3.4.1 Patterns of key benthic habitats in estuaries.....	81
3.4.2 Physical setting.....	83
3.4.3 Machine learning methods for prediction of key benthic habitats.....	85
3.4.4 Strengths, limitations and recommendations.....	86
Chapter 4: A Rapid Benthic Assessment approach for quantifying broad-resolution spatial changes in estuarine habitats.....	90
Abstract	90
4.1 Introduction	91
4.2. Methods	94
4.2.1 Study areas.....	94
4.2.2 Benthic habitat sampling technique.....	95
4.2.3 In situ seagrass sampling	97
4.2.4 Data Analysis.....	100
4.3 Results	102
4.3.1 Comparisons between the RBA and fine-resolution post-processed methods	102
4.3.2 Comparisons of seagrass cover between RBA and fine-resolution post-processing method	108
4.3.3 <i>In situ</i> seagrass sample comparison.....	111
4.4 Discussion.....	114
4.4.1 Strengths, limitations and recommendations.....	116
Chapter 5: General discussion	120
5.1 Discussion.....	120
5.1.1 Habitat patterns between permanently opened, seasonally opened and normally closed estuaries.....	122
5.1.2 Using Random Forests to model species distribution and abundance in estuaries...	125
5.1.3 Rapid characterisations of the seafloor.....	127
5.1.4 Implications for estuarine management.....	129
Appendix.....	131
Bibliography	138

List of Figures

Figure 3.1: The location of the five estuaries from this study in Western Australia. Red circles indicate the five estuaries surveyed, green squares represents cities and proportional dark red circles represent population of townships.	38
Figure 3.2: The location of video sampling sites in each estuary sampled in Western Australia, with underlying bathymetry	45
Figure 3.3: Small hand-deployable Raytech high-resolution towed-video system. System includes: (a) high-resolution video camera; (b) two 250 watt lights; (c) steel frame with dimensions 30 x 50 cm.	46
Figure 3.4: Image of the top-side unit containing: (a) Sony mini-DV cassette recorder; (b) video monitor; (c) coaxial cable connection to camera; (d) laptop computer is connected to GPS and programmable Cherry©Keyboard.	47
Figure 3.5: Relative composition of substratum and habitat-forming biota within and between the five estuaries, recorded from towed underwater video..	60
Figure 3.6: Maps of the predicted percent covers of <i>R. megacarpa</i> , red and green algal morphologies within five estuaries of south-west Australia.....	68
Figure 3.7: Maps of the predicted percent cover of <i>R. megacarpa</i> , <i>H. ovalis</i> and <i>H. tasmanica</i> in Leschenault Estuary.....	69
Figure 3.8: Maps of the predicted percent cover of <i>Ficopomatus enigmaticus</i> in three estuaries of south-west Australia and predicted coverage of <i>Mytilus edulis</i> in Wilson Inlet.	71
Figure 3.10: Partial plots for the four most influential response variables for: (a) <i>H. ovalis</i> ; (b) <i>H. tasmanica</i> in Leschenault Estuary.	73
Figure 3.11: Partial plots for the four most influential predictors for Green algae in: (a) Stokes Inlet; (b) Wellstead Estuary; (c) Beaufort Inlet; (d) Wilson Inlet..	74
Figure 3.12: Partial plots for the four most influential predictors for Red algae in: (a) Wellstead Estuary; (b) Beaufort Inlet; (c) Wilson Inlet; (d) Leschenault Estuary.....	75
Figure 3.13: Partial plots for the four most influential predictors in: (a) Stokes Inlet; (b) Wellstead Estuary; (c) Beaufort Inlet for Polychaete mounds; (d) Wilson Inlet for Mussel clumps.....	76
Figure 3.14: Maps of the standard deviation associated with predicted percent cover of <i>R. megacarpa</i> , red and green algal morphologies within five estuaries of south-west Australia.	78
Figure 3.15: Maps of the standard deviation associated with predicted percent cover of <i>R. megacarpa</i> , <i>H. ovalis</i> and <i>H. tasmanica</i> in Leschenault Estuary.	79

Figure 3.16: Maps of the standard deviations associated with the predicted percent cover of polychaete mounds in three normally closed estuaries and standard deviation associated with the predicted coverage of mussel clumps in Wilson Inlet.	80
Figure 4.1: Screen grabs from underwater video of the broad RBA percentage covers of seagrass: (a-c) Low, moderate and high percent cover of <i>R. megacarpa</i> ; (d-f) Low, moderate and high percent cover of <i>H. ovalis</i>	97
Figure 4.3: Percent occurrence of all taxa RBA percent occurrence of seagrass, morphologies of red and green algae and all other taxa within five estuaries of south-west Australia.....	103
Figure 4.4: Comparison between broad cover categories from the RBA method and the fine-resolution post-processing method in Chapter 3: (a) Leschenault Estuary; (b) Wilson Inlet; (c) Beaufort Inlet.	106
Figure 4.5: Comparison between broad cover categories from the RBA method and the fine-resolution post-processing method in Chapter 3: (a) Wellstead Estuary; (b) Stokes Inlet.	107
Figure 4.6: Comparison of <i>R. megacarpa</i> percent cover from Wilson Inlet along Transect 6: (a) Broad RBA percent cover; (b) fine-resolution percent cover.....	108
Figure 4.7: Comparison between the RBA method of broad percent cover categories and the fine-resolution percent cover from Chapter 3: (a) Box plot; (b) scatter plot. ..	110
Figure 4.8: Comparisons of broad scale estimates of <i>R. megacarpa</i> cover for low (n=9), moderate (n=9) and high (n=9) towed-video categories compared to <i>in situ</i> measures from benthic cores of: (a) <i>R. megacarpa</i> above-ground biomass (mean dry weight); (b) <i>R. megacarpa</i> density (mean number of shoots p/m); (c) <i>R. megacarpa</i> shoot length (mean dry weight).	112
Figure 5.1: Conceptual model of hydrodynamic regimes and habitats present in south-west Australian estuaries.....	124

List of Tables

Table 2.1: A review of the methods available for estimating abundance and percent cover from underwater video and lists their goals, advantages and disadvantages.	18
Table 3.1: The physiographic settings of the five estuaries surveyed in Western Australia	39
Table 3.2: Summary information on physical samples (water quality, pore water, sediment composition) collected from five south-west estuaries.	41
Table 3.3: Summary information on the number of towed video-transects and drop camera samples collected from the five south-west estuaries.....	43
Table 3.4: Summary of physical variables collected for each estuary collected in this study. Means and \pm Standard Error with minimum and maximum in brackets.....	54
Table 3.5: Summary of model performance using Random Forests for biological habitat-formers..	65
Table 4.1: Summary information on the number of <i>in situ</i> samples collected for <i>R. megacarpa</i> and <i>H. ovalis</i> from three south-west Australian estuaries.....	98
Table 4.2: Comparison of mean substratum percent cover between the RBA broad-resolution (30% categories) method and the fine-resolution (5% categories) method of post-processed percent cover of all estuaries.	104

Abstract

With the global carbon crisis a matter of worldwide concern, efforts to preserve natural habitats that sequester carbon are of utmost importance. However, the processes which enable aquatic plants to survive and thrive are poorly known, as is the extent of their distribution and how they change over multiple scales. The aim of this research was to develop methodologies to help define the relationships between key benthic habitats and bio-physical variables and spatially predict their distribution and abundance within south-west Australian estuaries through towed underwater video. This thesis identified multiple non-destructive methods along with their strengths and limitations, to characterise benthic cover from underwater video, and highlighted optimal methods based on equipment, end goals, time and funding available. Additionally, I emphasize that no one method used in isolation was suitable for the analysis of underwater video from the shallow and turbid habitats from my study sites, but that a combination of methods was required for optimal characterisation.

This research is one of the first to model and spatially predict fine-resolution (5% intervals) percent cover of benthic habitats within estuaries from post-processed underwater video using biological and physical datasets with a state-of-the art machine learning method called ‘Random Forests’. This method is often used within terrestrial landscape ecology, but rarely within estuarine systems. Random Forests performed well with 79-90% variation explained by the models for each key benthic habitat and partial plots illustrated strong relationships between physical variables and biotic habitats. The most influential parameters driving biotic habitat distributions were longitude (19%), depth (13%), and latitude (11%), although this relationship varied between estuaries and on the degree of estuary connectivity to the sea (permanently-opened, artificially-opened and normally-closed). Predictive performance of key benthic habitat models was moderate to excellent and associated uncertainty maps of standard deviation of each model was highly variable in areas of habitat fragmentation.

Broad-resolution distributions of biotic habitats were found to be important in understanding local-scale physical processes. Seagrasses were the most common biotic habitat in five estuaries, although higher numbers of seagrass species occurred in the permanently-opened Leschenault Estuary (e.g. *Ruppia megacarpa*, *Halophila ovalis* and *Heterozostera tasmanica*), while seasonally-opened (Wilson Inlet) and normally-closed

(Wellstead, Stokes and Beaufort) estuaries supported monospecific meadows of *R. megacarpa*. Red and green macroalgae had inverse latitudinal distributions, with red alga occurring in northern estuaries with higher amounts of seawater incursion and freshwater input. Green alga, especially green film alga were more prominent in the more stagnant, and normally-closed waters of the southern estuaries. Motile commercial fishery species such as crabs (*Portunus pelagicus*) were common in northern estuaries where access to marine influence was essential for their survival. Encrusting benthic polychaete worms such as *Ficopomatus enigmaticus* and the black mussel *Mytilus edulis* were found shallow sections of southern estuaries, which were able to tolerate extreme changes in water quality due to estuary bar closure, and often encrusting the hard substratum of submerged trees and rocks. This study demonstrated advances in modelling techniques of species abundances and distribution from underwater video and highlighted the importance of bio-physical relationships on spatial patterns of different seagrass species and other biotic habitats such as algae beds, polychaete mounds and mussel clumps in estuaries.

Estuarine habitats are at the forefront of climate change effects and experience rapid changes (within weeks to months) in their spatial distribution and abundance. I developed a real-time, rapid and accurate method to capture broad-resolution semi-quantitative (barren, low, moderate and high percent cover) changes in benthic habitats using underwater video, as traditional remote sensing methods such as aerial photography and satellite imagery can often take up to weeks and months to post-process for spatial habitat distribution. I tested the accuracy of two benthic habitat assessment protocols: the broad-resolution real-time classification protocol (called the “Rapid Benthic Assessment”) against the fine-resolution post-processed habitat classification. I also tested the validation of the broad-resolution percent cover categories of seagrass from the RBA method using in situ samples of *R. megacarpa* and *H. ovalis*. The high correlation between the RBA and the fine-resolution method indicated that a high degree of detail and accuracy was retained by the RBA method. The visualisation of benthic habitats almost impossible to map through traditional remote sensing means was made possible through rapid data acquisition and visualisation from underwater video. This study demonstrated that real-time delineation of estuarine habitats allowed for rapid data analysis and representation within hours of data collection.

This research will enable resource management authorities to make informed decisions on monitoring benthic habitats which have global significance within estuarine systems from baseline habitat maps, supplement existing maps and understand how bio-physical attributes shape benthic habitat distributions.

